Measure Information Template – Automated Demand Response

2013 California Building Energy Efficiency Standards

Document Version 10.1 submitted by: David S. Watson, Lawrence Berkeley National Lab. January 19, 2011 (minor modifications made on April 26, 2011)

CONTENTS

1. Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the 2008 California Building Energy Efficiency Standards. This template sets both the format and content of information needed to completely incorporate a measure into the Standards.

A separate report should be prepared for each measure or change proposed for consideration. The document should use the following headings and subheadings, which are explained in this document:

1. Purpose
2. Overview
    a. Project Title
    b. Description
    c. Type of Change
    d. Energy Benefits
    e. Non-Energy Benefits
    f. Environmental Impact
    g. Technology Measures
    h. Performance Verification
    i. Cost Effectiveness
    j. Analysis Tools
    k. Relationship to Other Measures
3. Methodology
4. Analysis and Results
5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices
6. Bibliography and Other Research
7. Appendices

2. Overview

Complete the following table, providing a brief sentence or two for each category of information.

a. Measure Title	Automated Demand Response (AutoDR) for non-residential buildings - HVAC

b. Description	**Applicable Domain:** Non-Residential buildings with new Energy Management and Control Systems (EMCS) for Heating, Ventilating and Air Conditioning (HVAC) systems **Background:** Clarifies details about the remotely generated automated demand (AutoDR) response signals. Links AutoDR signals to Title 24 2008 code known colloquially by the term, "Global Temperature Adjustment" (GTA). 2008 Title 24 GTA code follows: "SECTION 122 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS Space-conditioning systems shall be installed with controls that comply with the applicable requirements of Subsections pg 78 (h) Automatic Demand Shed Controls. HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for non-critical zones as follows: 1. The controls shall have a capability to remotely setup the operating cooling temperature set points by 4 degrees" **Description of proposed Title 24 2013 code:** Automated Demand Response (AutoDR) enables buildings to reduce electric demand upon the receipt of a remote signal from an electric utility, Independent System Operator (ISO) or the designated Curtailment Service Provider/Aggregator (CSP). This measure ensures that new commercial facilities (and those undergoing major renovation) include the technical capability to easily join automated DR programs in the future using nationally recognized open communication standards. The technical features of AutoDR described herein always allow facility operators the choice to "opt-out" of any demand response event. The costs associated with enabling AutoDR in commercial facilities in nominal, especially when added during construction. This measure does not require ratepayer participation in any particular utility or ISO DR program, nor does it require any utility or ISO to offer such DR programs. **Definition:** DEMAND RESPONSE SIGNAL is a signal sent by the local utility, or Independent System Operator (ISO) or their designated Curtailment Service Provider/Aggregator (CSP) indicating a price or a request to their customers to curtail electricity consumption for a limited time period. The team recognizes that efforts to finalize national DR standards are in process and may change in the future. Therefore the definition of a Demand Response signal will remain somewhat flexible at this time. The code language should be phrased so as to: 1) provide guidance to architects, engineers and contractors as they design and build systems in the future (i.e., they understand the intent of the code). 2) Prevent code language that could become irrelevant or counterproductive due to changes in AutoDR signal standards that may occur over the next several years. The language in this document uses phrasing to meet the aforementioned requirements: This measure ensures that new commercial facilities and those undergoing major renovation include the technical capability to easily join automated DR programs in the future using nationally recognized open communication standards. The technical features of AutoDR described herein always allow facility operators the choice to "opt-out" of any demand response event. The costs associated with enabling AutoDR in commercial facilities are nominal, especially when incurred during construction. Through the use of nationally recognized open communication standards, the value of the installed AutoDR infrastructure will persist over time. The use of proprietary solutions at the facility level will not be allowed as they would put these facilities at risk of vendor "lock-in" thus reducing the value of the AutoDR investment. Though national open standards may change or be enhanced over time, the open development process ensures that a low-cost or no-cost upgrade path is available to keep the building stock up to date with the latest software patches. This measure does not require ratepayer participation in any particular utility or ISO DR program, nor does it require any utility or ISO to offer such DR programs. DEMAND RESPONSIVE CONTROL is a control that is capable of receiving and responding to a demand response signal sent via a third-party network or. See proposed language section for more details.

c. Type of Change	Describe how the measure or change would be addressed in the California Building Energy Efficiency Standards, e.g., is the proposed change likely to be a mandatory measure, prescriptive requirement, or compliance option? Would it change the way that trade-off calculations are made? The following describes the types of changes in more detail: This mandatory measure requires some newly constructed nonresidential buildings to be AutoDR "ready". This measure clarifies functionality of an Energy Management Control System (EMCS) in newly constructed nonresidential buildings where EMCS are already required by the 2008 Building Energy Efficiency Standards

d. Energy Benefits

Describe the benefits of the change/measure proposed for 2011 Standards relative to 2008 Standards; if no current Standards are available, use current practice as the baseline. The proposer must identify:

1. Site energy: Electrical energy savings in kWh/yr, for a prototype building. For natural gas savings, identify savings in therms for a prototype buildings.
2. Electrical demand savings in kW for a prototype building
3. TDV energy savings for electricity and natural gas

The proposer must show all assumption and calculations used to derive the energy and demand savings for prototype buildings including but not limited to hours of operations, energy and demand savings per unit of equipment, and square footage of the prototype buildings; these assumptions must be consistent with the procedures described under the *Methodology* section below. Describe how Time Dependent Valuation (TDV) would affect benefits attributed to the measure. Reference the "*Analysis and Results*" section below for detailed calculations. If the proposed measure impacts more than one building prototype fill out this form for each prototype. Use the table below to document the energy savings resulting from the proposed measure;

	Electricity Savings (kwh/yr)	Demand Savings (kw)	Natural Gas Savings (Therms/yr)	TDV Electricity Savings	TDV Gas Savings
Per Unit Measure[1]					
Per Prototype Building[2]					
Savings per square foot[3]					

1. Specify the type of unit such as per lamp, per luminaire, per chiller, etc.
2. For description of prototype buildings refer to Methodology section below.
3. Applies to nonresidential buildings only.

AutoDR, and demand response in general provide dispatchable short-term load reductions (< 6 hrs.), as opposed to traditional energy efficiency [1]. Because the measure enables commercial buildings to shed electric loads on an "as needed" basis, it would likely be used in the following circumstances:

1) During an electric grid contingency event.
2) During a period of high electric prices (e.g., 3-6pm on critical peak pricing days).
3) Continuous grid balancing and ancillary services.

Each of the aforementioned circumstances has a strong correlation with periods of high Time Dependent Valuation (TDV).

For demand response with longer periods of advanced warning (e.g., day ahead programs), AutoDR can be used to enable pre-cooling strategies.

[1] Energy efficiency and load shifting programs are already addressed in the TDV methodology included in the 2008 Title-24 building energy standards.

e. Non-Energy Benefits	4. Identify non-energy benefits, such as comfort, reduced maintenance costs, improved indoor air quality, health and safety benefits, productivity, and/or increased property valuation. AutoDR, and demand response in general, provide peak load reduction on an as-needed basis. DR has benefits to society such as the ability to serve more ratepayers without the need for additional generation and transmission capacity. DR is useful in the increased integration of intermittent renewable energy sources. By automating DR using AutoDR technologies, demand response can be performed with less advanced notice, and has been proven to be more repeatable, persistent and reliable. Property values of AutoDR enabled sites may be higher due to the ability of these sites to participate in cost saving DR programs, if desired.

f. Environmental Impact

5. Does the change/measure have any potential adverse environmental impacts? Is water consumption increased? Is there impact on water quality and contaminants? Are there environmental or energy impacts associated with material extraction, manufacture, packaging, shipping to the job site, installation at the job site, or other activities associated with implementing the measure in buildings? Use the following tables to identify the environmental impact per unit of measure and prototype buildings and state your assumptions:

AutoDR has no negative environmental impact. AutoDR is a software feature added to new Energy Management and Control Systems (EMCS). In some cases and small hardware network gateway box is also included in the AutoDR system.

AutoDR and associated DR programs that it enables have a positive environmental impact. Peak load reduction can reduce the need to operate the least efficient and most polluting peaker plants that are used during system wide peaks in load. Environmental analysis is not provided in this document.

Material Increase (I): (All units are lbs, 1st install only)

	Mercury	Lead	Copper	Steel	Plastic	Others (Indentify)
Per Unit Measure[1]	0	0	<1 lbs during 1st install only. AutoDR gateway box.[3]	<1 lbs during 1st install only. AutoDR gateway box.[3]	<1 lbs during 1st install only. AutoDR gateway box.[3]	NA
Per Prototype Building[2]	0	0	<1 lbs during 1st install only. AutoDR gateway box.[3]	<1 lbs during 1st install only. AutoDR gateway box.[3]	<1 lbs during 1st install only. AutoDR gateway box.[3]	NA

1. Specify the type of unit such as per lamp, per luminaire, per chiller, etc.
2. For description of prototype buildings refer to Methodology section below.
3. Applicable to sites that use AutoDR gateway box only[2]. Sites that use AutoDR software (only) solution have zero material increase.

Water Consumption:

AutoDR does not have an impact on water consumption or quality.

[2] AutoDR functionality can be added through the addition of a small electronic gateway box (approx. 8" x 10" x 4") or added as software to an existing EMCS facility computer or other EMCS device.

g. Technology Measures	4. If the measure requires or encourages a particular technology, address the following, otherwise skip this section. **Measure Availability:** 5. Identify the principal manufacturers/suppliers who make the measure (product, technology, design strategy or installation technique), and their methods of distribution. Is the measure readily available from multiple providers? Comment on the current ability of the market to supply the measure in response to the possible Standards change and the potential for the market to ramp up to meet demand associated with the possible Standards change. If the measure needs further development and refinement in response to possible Standards changes, comment on if the measure will be available from several manufacturers by the effective date of the Standards. Identify competing products. See appendix A for list of nearly 50 companies that have integrated AutoDR client software into their products. The list includes major corporations such as Automated Logic Corp., Cisco, Echelon and Honeywell as well as many mid-sized and smaller manufacturers of controls and communications equipment for buildings and industrial facilities. **Useful Life, Persistence, and Maintenance:** Describe the life, frequency of replacement, and maintenance procedures related to the measure. How long will energy savings related to the measure persist? Is persistence related to performance verification, proper maintenance and/or commissioning? If there are issues related to persistence, how can they be addressed? (See Performance Verification below.) When provided as a standard product feature, AutoDR software can either be used immediately or else lie dormant until needed to enable DR. When the AutoDR software is in place, DR strategies can easily be initiated at any time, even years after original installation. The flexibility to enable or disable the AutoDR feature (without removing it) makes it very persistent. Once the AutoDR software is installed there is no reason for on-site facility managers to remove it. Though some seasonal set-up or maintenance may be required, AutoDR is not prone to wear, tear or degradation over time. Since the vast majority of commercial facilities have connectivity to the Internet, AutoDR (which has extremely low bandwidth requirements), should not incur any incremental cost.
h. Performance Verification of the Proposed Measure	In this section, identify the type of performance verification or commissioning that is needed in order to assure optimum performance of the measure. For residential buildings, field verification and diagnostic testing are required for many measures. For nonresidential buildings, the parallel is acceptance testing. Here are some questions to ask: Does the technology or design strategy need performance verification or commissioning to ensure that it is properly installed and/or performing as designed? How are energy performance, useful life and persistence of savings affected by performance verification or commissioning? What specific performance verification measures or requirements are needed to assure that the measure is properly installed and performing as designed? Acceptance testing should be performed by one or more of the following methods: 1) Observation of a demand shed test event triggered by a remote demand response signal server or other source. The remote signal source may be generated by a utility, ISO, or vendor test equipment. 2) Observation of on-site equipment that has been certified to be AutoDR compliant[3].

[3] AutoDR compliant products will be certified by the OpenADR Alliance, the ZigBee Alliance or similar trade organization. Certified products are listed on their web sites.

i. Cost Effectiveness

Costs: In commercial facilities that have factory installed AutoDR included in their EMCSs (recommended method), there is no added cost to a given building. Since the AutoDR feature resides in the software embedded in the standard control devices there is no added cost for hardware or software labor during installation. When the AutoDR feature is added as a separate component, the cost is approximately $75 per kW brought under control. For a typical 100,000 ft.^{2} office building the cost to a separate AutoDR device, including associated integration would be ~ $7500.

Benefits: The benefit of the AutoDR feature is dependent on the value of DR. Table 1 shows benefits based on the commonly used value for shed capacity of $85/kW per year. Table 1 uses 1.0 W/ft.^{2} for the shed amount. This value is based on field studies shown in Appendix C., table 2. Simple calculations indicate payback periods of between zero and one year. While the annual benefits of DR would continue to accrue, there is no cost to maintain the AutoDR feature, once it is installed.

Installation Scenarios	Cost	Cost/kW	Annual Benefit	Simple Payback (yrs)
Factory AutoDR (recommended method)	$0	$0	$8,500	Instant
Separate component AutoDR (alternate method)	$7500	$75	$8,500	0.9

Table 1 - Costs and benefits for a typical 100,000 ft.^{2} office building.
1) Sheds amounts and durations vary based on weather, building type and other factors. See table 2 for more detail.
2) Factory AutoDR feature is added in the EMCS manufacturer's factory.

j. Analysis Tools

List and describe the tools needed to quantify energy savings and peak electricity demand reductions resulting from the proposed measure. Can these benefits be quantified using the Standards reference methods (such as Calres for residential and EnergyPlus for nonresidential buildings)? What enhancements to the reference methods are needed, if any? If a measure is proposed as mandatory, then analysis tools are not relevant, since that measure would not be subject to whole building performance trade-offs.

Since the measure is recommended as mandatory, tools are note needed to quantify energy savings and peak electricity demand reductions.

k. Relationship to Other Measures	Identify any other measures that are impacted by this change. Explain the nature of the relationship. This measure enables remotely triggered automated demand response in commercial facilities. To achieve this functionality, the AutoDR signal must trigger a pre-programmed sequence of operations that will automatically shed electric load. Extensive research[4], field tests and utility[5] deployments have shown a strategy known as global temperature adjustment (GTA) to be most effective and least objectionable of those tested. Global Temperature Adjustment (GTA) allows commercial building operators to adjust the space temperature setpoints for an entire facility with a simple set of actions from one location (e.g., from one screen on the operator's workstation). GTA, as defined in title 24 2008, Sec. 122 (a)-(h) (see appendix 7B for full text) enables effective and graceful sheds of electric loads in commercial buildings that are implemented manually by building operators. This measure links the Global Temperature Adjustment (GTA) feature defined in 2008 to be remotely triggered. In addition, this measure links lighting systems that are capable of dimming or otherwise reducing their loads during demand response events.

[4] By the Lawrence Berkeley National Lab, Demand Response Research Center and others shown in section 5. Bibliography and Other Research

3. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

The following changes are proposed for 2013 Title 24 related to automated demand response (AutoDR) for HVAC systems.

In this document, formatting is used as follows:

1) Black normal font = contextual background information. (Like this!). Also used to show existing 2008 language that will remain unchanged in 2013.
2) Black normal font, underlined = new text, to be ADDED in 2013 version as agreed by the AutoDR for lighting stakeholder team in previous workshops.
3) Yellow highlighted font = proposed language, new for 2013 to be presented at the April 27th CEC Title 24 Staff Workshop.

Section 101(b) Definitions

DEMAND RESPONSE is short-term changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

DEMAND RESPONSE PERIOD is a period of time during which electricity loads are curtailed in response to a demand response signal.

DEMAND RESPONSE SIGNAL is a signal sent by the local utility, Independent System Operator (ISO), or designated curtailment service provider or aggregator indicating a price or a request to their customers to curtail electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL is a control that is capable of receiving and automatically responding to a demand response signal sent via a third-party network or device.

…

ENERGY MANAGEMENT CONTROL SYSTEM (EMCS) is often a computerized control system designed to regulate the energy consumption of a building by controlling the operation of energy consuming systems, such as the heating, ventilation and air conditioning (HVAC), lighting and water heating systems. The EMCS is also capable of monitoring environmental and system loads, and adjusting HVAC operations in order to optimize energy usage and respond to demand response signals. (See "DEMAND RESPONSE SIGNAL")

…

[5] AutoDr used by PG&E, SCE and SDG&E in field tests and various types of DR programs.

NIST FRAMEWORK AND ROADMAP FOR SMART GRID INTEROPERABILITY STANDARDS is NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 January 2010

…

SECTION 122 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

(h) Automatic Demand Shed Controls. HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for non-critical zones as follows:

1. The controls shall have a capability to remotely setup the operating cooling temperature set points by 4 degrees or more in all non-critical zones on signal from a centralized contact or software point within an Energy Management Control System (EMCS).
2. The controls shall have a capability to remotely setdown the operating heating temperature set points by 4 degrees or more in all non critical zones on signal from a centralized contact or software point within an EMCS.
3. The controls shall have capabilities to remotely reset the temperatures in all non critical zones to original operating levels on signal from a centralized contact or software point within an EMCS.
4. The controls shall be programmed to provide an adjustable rate of change for the temperature setup and reset.
5. . The Automatic shed controls shall be capable of the following modes:

i) "Disabled" by authorized facility operators.

ii) "Manual control" by authorized facility operators. Allows operators to adjust heating and cooling setpoints globally throughout the facility from a single point in the EMCS.

iii) "Automatic Demand Shed Control". Upon receipt of a remote DEMAND RESPONSE SIGNAL, the space conditioning-systems shall conduct a centralized demand shed for non-critical zones during the DEMAND RESPONSE PERIOD, as described in 122 (h) 1. and 122 (h) 2. above.

(proposed) SECTION 135

Demand Response Signals. Demand response signals shall conform to a communications standard from Table 4-1 in NIST Framework and Roadmap for Smart Grid Interoperability Standards.

(proposed) Future compliance manual language

Acceptable standards include OpenADR (Open Automated Demand Response) and ZigBee Smart Energy Profile.

OpenADR is defined by the following industry alliance:

OpenADR Alliance.
http://openadr.org

OpenADR is defined by the following standards development organization:
Organization for the Advancement of Structured Information Standards (OASIS), Energy Interoperation Technical Committee.
http://www.oasis-open.org/committees/workgroup.php?wg_abbrev=energyinterop

ZigBee Smart Energy Profile is defined by the following industry alliance:
http://www.zigbee.org/Standards/ZigBeeSmartEnergy/Overview.aspx

4. Appendices

If appropriate, use one or more appendices to present lengthy data tables, referenced studies, or other information that would otherwise disrupt the flow of the report.

Appendix A. List of AutoDR Client Implementers

	Vendor	Sector or Business	End-Use
1	Adura Technologies	Commercial	Lighting
2	Advanced Telemetry	Technology Integrator	Automation Systems
3	Advantech	Technology Integrator	Automation Systems
4	Automated Logic Corp	Commercial	HVAC
5	Beckhoff	Commercial	Lighting
6	BPL Global	Commercial/Residential	HVAC/Others
7	Cassatt Corp	Industrial	Data Center Servers
8	Cisco (Formerly Richards Zeta)	Commercial	HVAC/Lighting
9	Convergence Wireless	Commercial	Lighting
10	Cypress Systems	Commercial/Industrial	HVAC/Others
11	Eaton	Commercial	Lighting
12	Echelon i.LON Smart Server	Technology Integrator	Automation Systems
13	e-Radio USA	Technology Integrator	FM/RDS, UMC
14	Federspiel Controls	Commercial/Industrial	HVAC
15	Honeywell and Novar	Commercial/Industrial	HVAC/Others
16	Invensys/Wonderware	Industrial	SCADA/HMI
17	LumEnergi	Commercial	Lighting
18	Millennial Net	Commercial/Industrial	HVAC/Others
19	PowerIT Solutions	Industrial	Refrigeration
20	RTP Controls	Technology Integrator	Automation Systems
21	Site Controls	Technology Integrator	Automation Systems
22	Stonewater Control Systems	Technology Integrator	Automation Systems
23	Tendril	Residential	HVAC/Others
24	Universal Devices	Commercial/Residential	HVAC/Lighting/Others
25	Wattstopper	Commercial	Lighting

	Vendor	Sector or Business	End-Use
26	NA	Technology Integrator	Automation Systems
27	NA	Research Organization	Lighting
28	NA	Energy Consulting/Contracting	NA
29	NA	Commercial/Industrial	HVAC
30	NA	Energy Services	Commercial/Residential
31	NA	Technology Integrator	NA
32	NA	Technology Integrator	Automation Systems
33	NA	Commercial	Lighting
34	NA	Commercial/Residential	Energy Management
35	NA	Technology Integrator	Automation Systems
36	NA	Electricity Infrastructure	NA
37	NA	Industrial	Automation Systems
38	NA	Commercial	Automation Systems
39	NA	Industrial/Water	Automation Systems
40	NA	Commercial/Industrial	Automation Systems
41	NA	Technology Integrator	Automation Systems
42	NA	Commercial/Industrial/Residential	Energy Management
43	NA	Commercial	Lighting
44	NA	Technology Integrator	Automation Systems
45	NA	Commercial/Industrial/Residential	Automation Systems/Others
46	NA	Technology Integrator	Energy Management
47	NA	NA	NA
48	NA	Technology Integrator	HVAC/Lighting/Others
49	NA	Commercial/Industrial	Automation Systems
50	NA	Commercial/Industrial	Automation Systems
51	NA	Commercial/Industrial	HVAC/Lighting/Others
52	NA	NA	NA

Appendix B.
Text describing Global Temperature Adjustment Feature in the CA Energy Code title 24 2008

Title 24 2008, Pg 76

SECTION 122 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS
Space-conditioning systems shall be installed with controls that comply with the applicable requirements of Subsections
(a) through (h).
(a) Thermostatic Controls for Each Zone. The supply of heating and cooling energy to each space-conditioning zone
or dwelling unit shall be controlled by an individual thermostatic control that responds to temperature within the zone
and that meets the applicable requirements of Section 122(b).
….
pg 78
Final code language for GTA (global temperature adjustment) shown below:

(h) Automatic Demand Shed Controls. HVAC systems with DDC to the Zone level shall be programmed to allow
centralized demand shed for non-critical zones as follows:

1. The controls shall have a capability to remotely setup the operating cooling temperature set points by 4 degrees or
more in all non-critical zones on signal from a centralized contact or software point within an Energy Management
Control System (EMCS).

2. The controls shall remotely setdown the operating heating temperature set points by 4 degrees or more in all non
critical zones on signal from a centralized contact or software point within an EMCS.

3. The controls shall have capabilities to remotely reset the temperatures in all non critical zones to original operating
levels on signal from a centralized contact or software point within an EMCS.

4. The controls shall be programmed to provide an adjustable rate of change for the temperature setup and reset.

Title 24 2008, Pg 89

SECTION 125 – REQUIRED NONRESIDENTIAL MECHANICAL SYSTEM ACCEPTANCE
(a) Before an occupancy permit is granted the following equipment and systems shall be certified as meeting the Acceptance
Requirements for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of
Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the
acceptance requirements:
1. Outdoor air ventilation systems shall be tested in accordance with NA7.5.1
2. Constant volume, single zone unitary air conditioning and heat pump unit controls shall be tested in accordance with
NA7.5.2.
3. Duct systems shall be tested in accordance with NA7.5.3 where either:
A. They are new duct systems that meet the criteria of Sections 144(k)1, 144(k)2, and 144(k)3; or
B. They are part of a system that meets the criteria of Section 149(b)1D.
4. Air economizers shall be tested in accordance with NA7.5.4.
EXCEPTION to Section 125(a)4: Air economizers installed by the HVAC system manufacturer and certified to
the Commission as being factory calibrated and tested are not required to be field tested per NA7.5.4.2.

5. Demand control ventilation systems required by Section 121(c)3 shall be tested in accordance with NA7.5.5
6. Supply fan variable flow controls shall be tested in accordance with NA7.5.6
7. Hydronic system variable flow controls shall be tested in accordance with NA7.5.7 and NA7.5.9
8. Boiler or chillers that require isolation controls per Section 144(j)2 or 144(j)3 shall be tested in accordance with
NA7.5.7
9. Hydronic systems with supply water temperature reset controls shall be tested in accordance with NA7.5.8
10. Automatic demand shed controls shall be tested in accordance with NA7.5.10.

Appendix C.

Site name	Area (ft^2)	strategy used	# Days of testing	Average shed (W/ft^2)*	Peak shed (W/ft^2)	Outside temperature at time of peak
GSA Oakland Federal Building	978,000	Global Temp Adjustment	4	0.30	1.10	88
Contra Costa County 2350 Arnold	131,000	Global Temp Adjustment	2	0.30	0.67	90
Contra Costa County 50 Douglas	90,000	Global Temp Adjustment	2	0.58	1.34	90
GSA Santa Rosa Federal Building	80,000	Global Temp Adjustment*	20	1.50	2.40	95
Sacremento County Building	80,000	Global Temp Adjustment*	3	0.75	1.00	70
Cisco	4,354,000	Global Temp Adjustment & other strategies	1	0.16	0.20	
Echelon		Global Temp Adjustment & other strategies	2	0.89	1.22	

Table 2. Results from LBNL Demand Response research tests conducted in 2003 and 2004 in Commercial facilities throughout California.

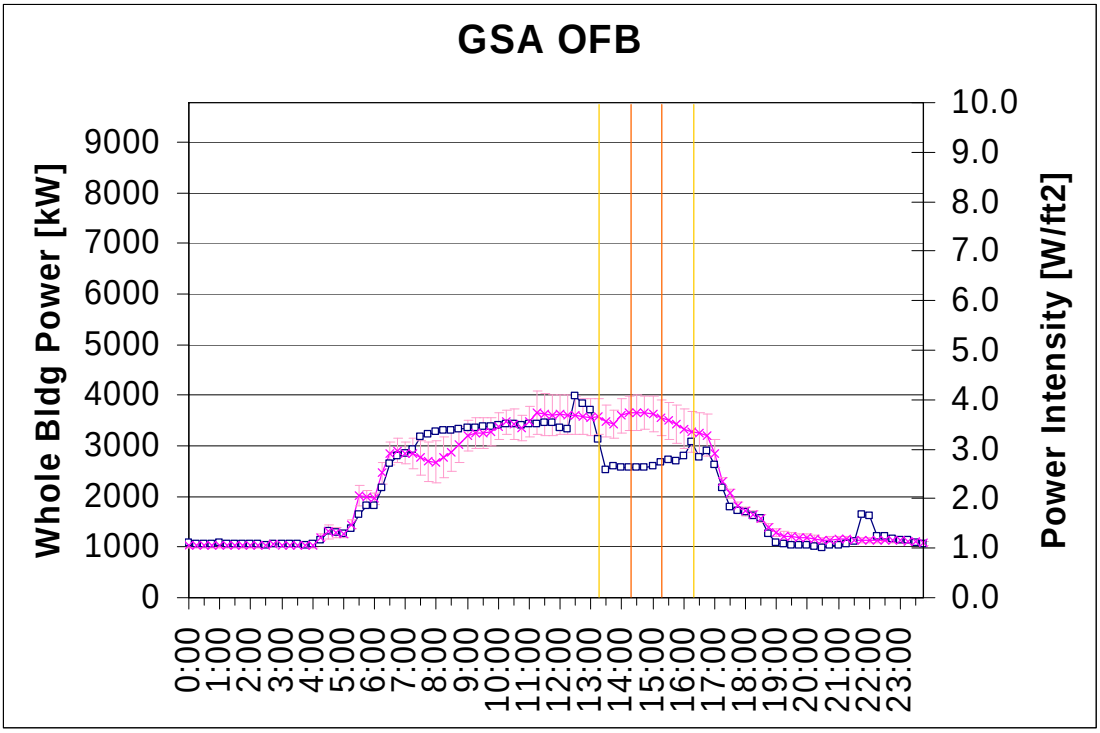

Figure 1. Oakland Federal GSA building on September 8, 2004. AutoDR using Global Temperature Adjustment was initiated at 13:00 and returned to normal at 16:00.

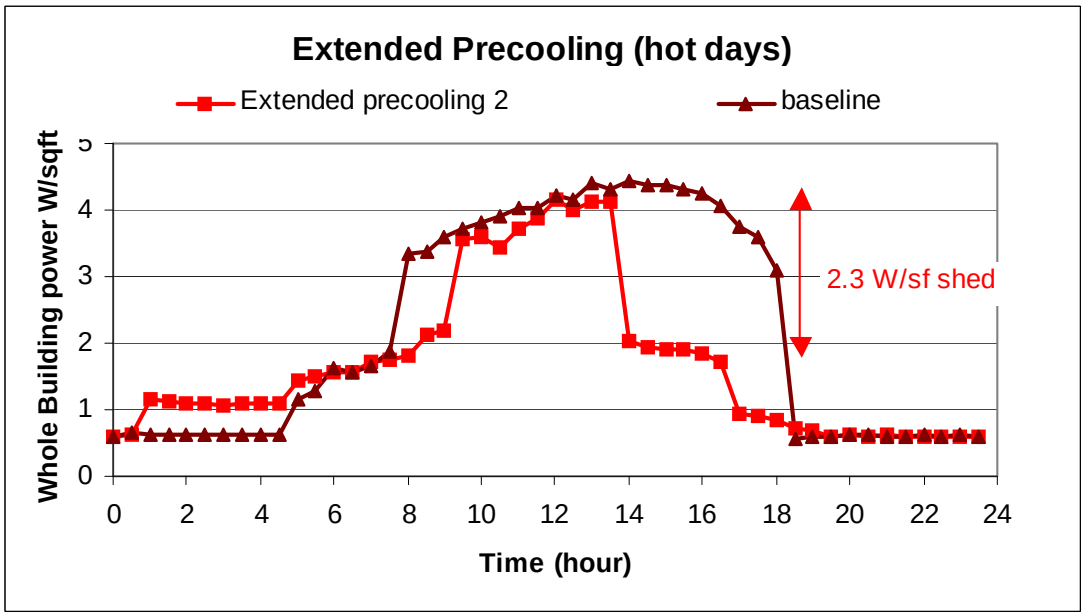

Figure 2. Santa Rosa Federal GSA building in the summer 2004. Pre-cooling was initiated before occupancy using Global Temperature Adjustment. AutoDR was used for all communications with the site.

5. Bibliography and Other Research

Findings from the 2004 Fully Automated Demand Response Tests in Large Facilities
Piette, M.A., D.S. Watson, N. Motegi, and N. Bourassa, Lawrence Berkeley National Laboratory. LBNL-58178. September 2005. Abstract

Development and Evaluation of Fully Automated Demand Response in Large Facilities
Piette, M. A., O. Sezgen, D. Watson, N. Motegi, (Lawrence Berkeley National Laboratory), C. Shockman (Shockman Consulting), L. ten Hope (Program Manager, Energy Systems Integration CEC). CEC-500-2005-013. January 2005

Peng Xu, Philip Haves, MaryAnn Piette, James Braun. 2004. Peak demand reduction from pre-cooling with zone temperature reset in an office. Proceedings of 2004 ACEEE summer study on energy efficiency in buildings. Pacific Grove, CA. LBNL-55800.

Peng Xu, Philip Haves. 2005. Case Study of Demand Shifting With Thermal Mass in Two Large Commercial Buildings. ASHRAE Transactions. In Press. LBNL-58649.

Philip Haves, Peng Xu, MaryAnn Piette, Satkartar Kinney, Lixing Gu. 2001. Demand Relief and Weather Sensitivity in Large California Commercial Office Buildings. Presented at 2001 ICEBO Conference, LBNL-48285.

Integrating Renewable Resources in California and the Role of Automated Demand Response
Sila Kiliccote, Pamela Sporborg, Imran Sheikh, Erich Huffaker, Mary Ann Piette
LBNL-4189E, November 2010

Design and Operation of an Open, Interoperable Automated Demand Response Infrastructure for Commercial Buildings, Piette, Mary Ann, Girish Ghatikar, Sila Kiliccote, David Watson, Ed Koch, and Dan Hennage, Journal of Computing Science and Information Engineering 9, no. 2 (2009). LBNL-2340E